Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Interference Immunity Performance Specifications for Radio Receivers	)	ET Docket No. 03-65
	)	
	)	
Review of the Commission's Rules and Policies Affecting the Conversion to Digital Television	)	MM Docket No. 00-39
	)	

COMMENTS OF THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

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EXECUTIVE SUMMARY

The National Telecommunications and Information Administration (NTIA) supports the Federal Communications Commission (Commission) in its efforts to consider the adoption of interference immunity performance specifications for non-government radio receivers. NTIA has adopted immunity standards for federal receivers in its *Manual of Regulations and Procedures for Federal Radio Frequency Management*. These standards cover a large percentage of federal operations. NTIA believes these standards have done much to prevent interference to federal users of the spectrum. They have also permitted NTIA to utilize the spectrum more efficiently by providing minimum performance levels that can be assumed in service planning and frequency coordination processes.

NTIA urges the Commission to initiate a proceeding to consider appropriate interference immunity performance standards for the private sector as well. NTIA has seen instances where interference problems have occurred due to a lack of receiver immunity to non-cochannel signals and believes that incorporating receiver standards will eliminate many of these problems. NTIA also believes that the implementation of receiver standards will permit more effective management of spectrum resources as they will permit reliable predictions of the effect of new transmitters on non-cochannel receivers in the environment. By enabling tighter packing of assignments in a particular band, standards may also facilitate more efficient use of the spectrum.

NTIA also recommends that the Commission give priority to recently allocated or reallocated bands, especially those reallocated from the federal government, before these bands become filled with receivers not conforming to any standards.

NTIA concurs with the Commission's approach of considering various frameworks for standards, including voluntary or mandatory, service specific or generic, and equipment

standards or environmental reports The approach selected by the Commission should be effective, yet flexible and impose a minimum of hardship and costs on the users of the spectrum

NTIA has recently completed the first phase of a study on receiver spectrum standards and has published NTIA Report 03-404, *Receiver Spectrum Standards, Phase 1, Summary of Research into Existing Standards*. By including the NTIA Report as part of these comments, NTIA hopes to draw attention to the extensive work already performed in the area of receiver standards by the various industry organizations. These organizations have already developed voluntary standards that have proven very successful and NTIA urges the Commission to rely on them to the extent appropriate.

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COMMENTS OF THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

The National Telecommunications and Information Administration (NTIA), an Executive Branch agency within the Department of Commerce, is the President's principal adviser on domestic and international telecommunications policy, including policies relating to the nation's economic and technological advancement in telecommunications. Accordingly, NTIA makes recommendations regarding telecommunications policies and presents Executive Branch views on telecommunications matters to the Congress, the Federal Communications Commission (Commission), and the public. NTIA, through the Office of Spectrum Management, is also responsible for managing the federal government's use of the radio frequency spectrum. NTIA respectfully submits the following comments in response to the Commission's Notice of Inquiry in the above-captioned proceeding.[1]

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[1] *In the Matter of Interference Immunity Performance Specifications for Radio Receivers*, ET Docket No 03-65, Notice of Inquiry, 68 Fed Reg 23677 (May 5, 2003) ("NOI").

I. BACKGROUND

The Spectrum Policy Task Force recommended that the Commission consider applying receiver performance requirements, and that a Notice of Inquiry (NOI) be pursued as part of this effort.[2] The Commission responded with the present NOI which requests comments on the following areas: current receiver environment; performance and standards; possibilities of improving receiver immunity; potential impact of receiver standards; possible approaches to achieving desired levels of performance; considerations that should guide the Commission's approach; and issues relating to the possible incorporation of receiver immunity performance incentives, guidelines, or standards.

II. NTIA APPLAUDS THE COMMISSION FOR BEGINNING TO CONSIDER THE ADOPTION OF RECEIVER INTERFERENCE IMMUNITY STANDARDS TO REDUCE INTERFERENCE AND INCREASE SPECTRUM EFFICIENCY.

For many years, NTIA has imposed receiver immunity standards on the federal sector through its *Manual of Regulations and Procedures for Federal Radio Frequency Management*.[3] A large percentage of the current federal frequency assignments are subject to mandatory receiver spectrum standards.[4] NTIA believes the adoption of receiver immunity standards has greatly minimized interference to federal systems. NTIA believes the adoption of receiver spectrum standards will result in a significant reduction in instances of interference and permit a notable increase in the efficiency of the use of the radio spectrum.

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[2] *Spectrum Policy Task Force Report*, Federal Communications Commission, ET Docket No 02-135 at 31, 33 (November 15, 2002) ("FCC Task Force Report")

[3] *Manual of Regulations & Procedures for Federal Radio Frequency Management*, National Telecommunications and Information Administration (2003).

[4] National Telecommunications and Information Administration, *Receiver Spectrum Standards, Phase 1, Summary Of Research Into Existing Standards*, NTIA Report No 03-404 at 7 (November 2003) ("NTIA Report No 03-404")

The Commission has established transmitter parameters (e g., transmit power and emission characteristics) in given portions of the spectrum in which the nature of radio signals is well understood and generally predictable by equipment manufacturers and licensees. In the absence of receiver immunity standards, the Commission has had to assume levels of receiver performance as a basis for certain existing rules.[5] Likewise, in selecting frequency assignments, public system operators and frequency coordinators must assume receiver immunity performance levels in many cases. Such assumptions may either risk interference or foster inefficient use of the spectrum. The Commission notes that the dramatic increases in the overall demand for spectrum-based services, rapid technical advances in radio systems, and the need for increased access to the limited spectrum resource in recent years are straining the effectiveness of the Commission's longstanding spectrum policies. These changes have prompted the Commission to provide incentives for users to migrate to more efficient uses of the spectrum.[6] NTIA believes that this migration can be facilitated by specifying both transmitter and receiver standards.

NTIA has recently published the first phase of a study on receiver standards, NTIA Report No. 03-404. A copy of this report is provided in Appendix A to these comments and NTIA urges the Commission to consider it in its decisions. As discussed in this report, NTIA has mandatory receiver spectrum standards for most federal users of the radio spectrum. NTIA has taken the approach that the performance of both the transmitter and the receiver should be regulated. This approach to management of the radio spectrum emphasizes prevention of interference and spectrum use efficiency Some federal agencies implement even stricter

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[5] NOI at ¶ 6

[6] FCC Task Force Report at 11-15, NOI at ¶ 6

standards.[7] Therefore, these standards do not prevent users from moving to more efficient technologies or better receiver performance than required, but they establish a baseline.

NTIA offers the following comments to specific issues raised in the NOI.

III. NTIA URGES THE COMMISSION TO INITIATE A RULEMAKING TO ADOPT APPROPRIATE INDUSTRY-DEVELOPED VOLUNTARY STANDARDS.

In its study of receiver standards, NTIA has observed that there are many existing standards developed by US and international industry associations.[8] Adherence to these standards has done much to lessen the likelihood of interference for many services. NTIA recommends that the Commission initiate a proceeding to adopt these standards on a voluntary or recommended basis. These standards have been devised by industry representatives who are familiar with the various services and what is economically feasible. These standards bodies include among others, the Telecommunications Industry Association (TIA), the Consumer Electronics Association (CEA), the Radio Technical Commission for Aeronautics (RTCA), the International Telecommunications Union (ITU), the International Civil Aviation Organization (ICAO), the European Telecommunication Standard Institute (ETSI), and the International Electrotechnical Committee (IEC).[9] To maintain a cooperative relationship with those organizations managing voluntary standards and to draw on their expertise, NTIA concurs with the Commission's recommendations that these organizations be deeply involved in the standards process [10]

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[7] NTIA Report No. 03-404 at 35.

[8] Examples of many of these standards are given in NTIA Report No. 03-404

[9] NTIA Report No 03-404 at 15-34

[10] NOI at ¶ 19

IV. MANY RECENT INSTANCES OF INTERFERENCE COULD HAVE BEEN PREVENTED BY RECEIVER STANDARDS.

NTIA believes that receiver designs that do not take into account their operational environment are often vulnerable to interference from non-cochannel signals because of inadequate selectivity or other unwanted signal suppression provisions. NTIA has investigated a number of instances of reported interference that could have been avoided if appropriate receiver standards had been applied Some examples enumerated in NTIA Report 03-404 include the following: commercial fixed-satellite service receiving earth stations that use low noise amplifiers at the antenna and have little or no filtering prior to active components,[11] commercial digital radio relay receivers which use low noise amplifiers with little or no filtering prior to active components,[12] consumer unlicensed Part 15 receivers such as garage door openers which use very wide bandwidths,[13] analog television and other consumer receivers with generally very poor Radio Frequency selectivity,[14] commercial Very High Frequency (VHF) Maritime receivers with insufficient selectivity resulting in interference from National Oceanic and Atmospheric Administration (NOAA) weather broadcasts and land mobile transmitters.[15] Another example

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[11] National Telecommunications and Information Administration, *Analysis of Electromagnetic Compatibility Between Radar Stations and 4 GHz Fixed-Satellite Earth Stations*, NTIA Report No 94-313 (July 1994)

[12] National Telecommunications and Information Administration, *Ground-Based Weather Radar Compatibility with Digital Radio-Relay Microwave Systems*, NTIA Report No 90-260 (March 1990).

[13] National Telecommunications and Information Administration, *Measured Characteristics of Selected Non-Licensed Devices*, NTIA Technical Memorandum 91-149 (April 1991), Haley, J, *Navy can't close door jams*, Everett Herald, Everett (June 5, 1998)

[14] Transcript (Trans) of *Federal Communications Commission Interference Protection Public Workshop*, at 133 (August 2, 2002) (*available at* http //www fcc gov/sptf/files/0802fcc pdf).

[15] National Telecommunications and Information Administration, *Evaluation of Marine VHF Radios Performance in the Savannah, Ga and New Orleans, La Port Areas*, NTIA Report No 99-362 (April 1999)

not mentioned in the report are wireless cable system receivers with insufficient selectivity resulting in interference from Air Traffic Control radars in the 2700 to 2900 MHz band.[16]

V. ADOPTION OF RECEIVER STANDARDS WILL PERMIT MORE EFFICIENT USE OF THE RADIO FREQUENCY SPECTRUM.

The lack of receiver spectrum standards makes the determination of potential interference and frequency assignment practices difficult. Receiver performance is often characterized by assumptions or manufacturers specifications, and the latter may not be available. This prevents the efficient assignment of frequencies, as there is no sure way to assess the susceptibility of receivers to new transmitters placed in their environment.

As the Commission states in the NOI, receiver improvements could also provide greater opportunities for access to the spectrum.[17] The Commission further states that improving the general level of receiver performance with respect to interference immunity would allow increased operation of radio services on adjacent channels and frequency bands and thereby promote spectrum sharing and radio system interoperability that would permit more efficient use of the spectrum.[18] NTIA concurs with the Commission in that the increased demands placed on the radio spectrum can be accommodated through greater spectrum utilization efficiency. Currently adjacent or semi-adjacent channels cannot be assigned in the same or nearby areas in some services. This results in many potential assignments being unavailable. One well-known example is the practice not to assign adjacent analog television channels in the same area due to poor receiver selectivity. As stated in the Commission's Interference Protection Public

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[16] Comments of Federal Aviation Administration (July 20, 2003).

[17] NOI at ¶ 1

[18] NOI at ¶ 10

Workshop, had certain television receiver standards been implemented, this frequency assignment constraint would not have been necessary and there would have been adequate television channels to satisfy demand.[19]

As the Commission states in the NOI, one effect of minimally performing receivers has been demonstrated as licensees seek protection for service predicated on the performance of receivers with little tolerance for other signals. Had the expected performance characteristics of these receivers been defined, these services could have been developed with receivers that could better tolerate the introduction of new services on the same or proximate frequencies.[20]

NTIA believes that knowledge of the expected immunity performance to non-cochannel signals is required to be able to assess the likelihood of interference from new transmitters and to more effectively and efficiently manage spectrum resources.

VI. NTIA RECOMMENDS THAT THE COMMISSION GIVE FIRST PRIORITY TO ADOPTING STANDARDS FOR NEW ALLOCATIONS.

As the Commission states in the NOI, with the large number of communications services that are currently in operation, a program to study and define minimum receiver performance specifications across all radio services will be a substantial undertaking. The Commission requests comment and suggestions on how to plan for and manage such a program should it be undertaken. In particular, comments and suggestions are requested regarding the services and/or receiver types with which to begin.[21]

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[19] NTIA Report No 03-404 at 2, Trans at 133

[20] NOI at ¶ 2

[21] NOI at ¶ 24

NTIA recommends that the Commission give priority to considering those services that are newly developing and where there are few legacy receivers. Because of the lack of legacy systems in these bands, a decision by the Commission to implement receiver standards would have the greatest opportunity to be effective Among others, these bands include many of the recently reallocated bands previously used by the Federal Government. Although not necessarily newly allocated, NTIA also recommends that the Commission give priority to those bands adjacent to government bands where the latter have high power transmitters.

Of particular concern to NTIA are the bands that have recently been reallocated from the Federal Government to the private sector Because of the large spectrum requirements of the Federal Government and the mandate to avoid excessive costs or serious degradation to federal operations, most of these bands were identified with some degree of encumbrance. These encumbrances generally include continued federal operations within certain bands at specific sites and continued federal operations in adjacent bands. Introduction of new services and systems in these bands could open up a significant number of potential adjacent band interference problems. In the *Spectrum Reallocation Final Report*, NTIA stated "in order to achieve the goals set by Title VI for development of new technologies, adoption of effective receiver standards, either regulatory or established by industry, is essential for bands identified in the final plan that are adjacent to high-power federal systems."[22]

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[22] National Telecommunications and Information Administration, *Spectrum Reallocation Final Report, Response to Title VI – Omnibus Budget Reconciliation Act of 1993,* NTIA Special Publication 95-32 at v (February 1995)

VII. NTIA SUPPORTS THE COMMISSION'S FLEXIBLE APPROACH TO ADOPTING RECEIVER STANDARDS.

In developing receiver immunity performance standards, NTIA agrees with the Commission that many different approaches, including voluntary and mandatory, service specific and generic, as well as other options should be considered.[23]

Voluntary standards could be self-enforced by the Commission only protecting services for which receivers meet the recommended standard. Labeling could also be used to induce consumers to procure equipment meeting standards. In addition, as the Commission stated in its *Changes to the Rules Relating to Noncommercial Educational FM Broadcast Stations*, the Commission could let it be known that if voluntary standards are not sufficient, then mandatory standards could be imposed.[24] Other areas of flexibility are suggested in the NTIA Report.[25] NTIA urges the Commission to work with industry to develop an approach that will be effective, but impose a minimum of hardship and disruption.

VIII. CONCLUSION

NTIA supports the Commission's efforts in considering the inclusion of interference immunity performance standards for radio receivers in its regulations. NTIA urges the Commission to consider carefully the issues raised in these comments and in the NTIA Report.

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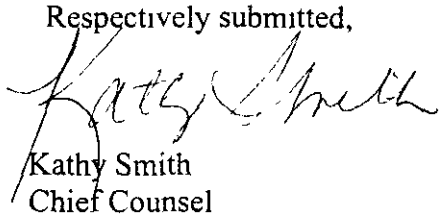
[23] NOI at ¶ 18

[24] *Changes to the Rules Relating to Noncommercial Educational FM Broadcast Stations,* Memorandum Opinion and Order, Docket No 20735, FCC 85-328 (released June, 1985).

[25] NTIA Report No 03-404 at 36

NTIA looks forward to working with the Commission and industry in developing the appropriate regulatory framework to accomplish this important task.

Respectively submitted,



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APPENDIX A

NTIA Report 03-404

RECEIVER SPECTRUM STANDARDS

Phase 1 - Summary of Research into Existing Standards

NTIA Report 03-404

RECEIVER SPECTRUM STANDARDS
Phase 1 - Summary of Research into Existing Standards

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NOVEMBER 2003

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EXECUTIVE SUMMARY

As part of the overall spectrum management process, the National Telecommunications and Information Administration (NTIA) and the Federal Communications Commission (FCC) have developed radio regulations to help ensure that the various radio services operate compatibly in the same environment without unacceptable levels of radio frequency interference. These regulations generally focus on sharing spectrum and the interfering potential of transmitters. Less attention has been given to the regulation of receiver parameters and the associated non-cochannel interference issues.

In recent years, there have been a growing number of cases of non-cochannel interference that has been caused by inadequate performance of receivers instead of by transmitter performance. One element in the prevention of non-cochannel interference is the design and use of quality receivers that are less susceptible to interference. Receivers are often vulnerable to interference from non-cochannel signals because of inadequate selectivity. This has resulted in complaints of interference, sometimes requiring legitimate transmitting stations to cease or limit their operation even when a poor performing receiver is mainly at fault. In addition to interference problems, the lack of receiver standards has hindered efficient management of the spectrum by putting restraints on adjacent channel assignments in many areas.

The objective of this task is to undertake a broad review of receiver spectrum standards to characterize their status and to explore needs and options for promoting the use of more interference-robust receivers. The first phase includes the identification of existing standards, both mandatory and voluntary. This report presents the results of this first phase. The second phase will examine the underlying requirements, assess trade-offs among potential regulatory approaches and develop appropriate recommendations.

With the exception of certain television services, the FCC has not published receiver spectrum standards and has allowed the marketplace to determine the appropriate receiver specifications. Realizing that poorly designed receivers can cause interference and limit the number and type of transmitters that can operate within a given environment, the FCC is now considering the adoption of receiver standards On March 13, 2003, the FCC adopted a Notice of Inquiry (NOI) to this effect. The NOI requests, *inter alia*, comments on standards that could be mandatory or voluntary.

NTIA, on the other hand, has receiver spectrum standards for most Federal users of the radio spectrum NTIA has taken the approach that, for Federal users, the performance of both the transmitter and the receiver should be regulated. This approach to management of the radio spectrum emphasizes prevention of interference and improved spectrum management. Federal agencies generally comply with the NTIA standards, with some agencies implementing even stricter standards.

Industry associations and standards setting bodies have published receiver spectrum standards for some radio services Many manufacturers adhere to these standards in the interest

of providing systems that perform adequately in adverse operational environments. However, few standards exist for many non-Federal services and frequency bands.

Many foreign countries have implemented receiver spectrum standards. Usually, rather than developing standards themselves, they adopt standards issued by the various international industry and inter-governmental associations.

The second phase of this study and follow-up work will include an examination of the need for standards, working with the FCC to establish standards or other means for preventing non-cochannel interference and promoting efficient use of the spectrum, updating the Federal standards in the NTIA manual, and the initiation of a program for greater promulgating emission characteristics in the Federal bands.

GLOSSARY

ADF	Automatic Direction Finding
AGC	Automatic Gain Control
AM	Amplitude Modulated
CB	Citizens Band
CEA	Consumer Electronics Association
CW	Continuous Wave
dB	decibels
dBm	decibels above one milliwatt
dBW	decibels above one watt
DME	Distance Measuring Equipment
DOD	Department of Defense
EIA	Electronic Industries Association
EMC	Electromagnetic Capability
ETSI	Electronic Telecommunications Standards Institute
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FCC	Federal Communications Commission
FM	Frequency Modulation
HF	High Frequency (3 to 30 MHz)
ICAO	International Civil Aviation Organization
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
ILS	Instrument Landing System
IM	Intermodulation
IMO	International Maritime Organization
ITU	International Telecommunications Union
kHz	Kilohertz
kW	Kilowatt
MF	Medium Frequency (.3 to 3 MHz)
MHz	Megahertz
MIL-STD	Military Standard
NDB	Non-Directional Beacon
NTIA	National Telecommunications and Information Administration
PCS	Personal Communications Service
PM	Phase Modulated
RTCA	Radio Technical Commission for Aeronautics
RTCM	Radio Technical Commission for Maritime Services
SMR	Specialized Mobile Radio
TIA	Telecommunications Industry Association
TSO	Technical Standard Order
UHF	Ultra High Frequency (300 to 3000 MHz)
VHF	Very High Frequency (30 to 300 MHz)

VOR	VHF Omni-directional Range
µvolt	Microvolt
V/m	Volts per meter

Section 1
INTRODUCTION

1.1 Background

As part of the overall spectrum management process, NTIA and the FCC have developed radio regulations to facilitate operation of various radio services in the same environment without unacceptable levels of radio interference. These regulations generally focus on sharing spectrum and the interfering potential of transmitters. Less attention has been given to the regulation of receiver parameters and the associated non-cochannel interference issues.

In recent years, there have been a number of cases of non-cochannel[1] interference that have been caused by the inadequate performance of receivers instead of by transmitter performance. One element in the prevention of non-cochannel interference and improvement in spectrum utilization efficiency is the design and use of receivers that are less susceptible to interference. Some of the reasons why these interference and efficiency problems are now becoming apparent may include:

1) continued dramatic increase in overall spectrum use;

2) mix of analog and digital technologies that have different spectral requirements, channel plans and interference suppression capabilities;

3) introduction of new services and systems without adopting standards needed for electromagnetic compatibility with incumbent services and systems;

4) design tradeoffs favoring inexpensive radio equipment rather than good equipment performance;

5) reduction or loss of previously available guard bands;

6) equipment manufacturers' lack of knowledge of characteristics of equipment operating in the same or adjacent bands;

7) increased receiver front-end bandwidth associated with greater tuning range of certain receivers; and

8) different system channel plans in the same band e.g. specialized mobile radio (SMR) and public safety operations sharing the 800 MHz band.[2]

Receiver designs that do not take into adequate account the operational environment are often vulnerable to interference from non-cochannel signals because of inadequate dynamic range or selectivity within the Radio Frequency (RF) or Intermediate Frequency (IF) stages of the receiver Some examples of interference due to inadequate receiver design that have been investigated by NTIA include the following:

1) Fixed-satellite service receiving earth stations that use low noise preamplifiers at the antenna and have little or no filtering prior to active components,[3]

2) Digital radio relay receivers that use low noise preamplifiers and have little or no filtering prior to active components,[4]

3) Unlicensed Part 15 receivers, such as garage door openers, that use very wide bandwidths,[5]

4) Analog television and other consumer receivers with generally very poor RF selectivity,[6] and

5) VHF maritime receivers with insufficient selectivity.[7]

In the U.S. regulatory environment, it sometimes is not clear whether interference problems resulting from design faults in the receiver are the responsibility of the receiver owner or the transmitter owner to resolve. Without standards, the quality of the receiver and its interference susceptibility is left to the buyer of a piece of radio equipment as an aspect of market-place choices. Nevertheless, user reaction to interference, in some cases public reaction, may place the onus on changing transmitter operations regardless of the actual cause of the interference.

The increased demands placed on the radio spectrum require effective spectrum management. Currently, efficient spectrum utilization is not achieved due to limitations on the assignment of adjacent or semi-adjacent channels in the same or nearby areas in some services. This results in many potential assignments being unavailable One well-known example is the practice by the FCC not to assign adjacent analog television channels in the same area due to poor receiver selectivity. Had television receiver standards been implemented, this frequency assignment constraint would not have been necessary and there would have been adequate television channels to satisfy demand.[8]

In response to the *Omnibus Budget Reconciliation Act of 1993* and the *Balanced Budget Act of 1997*, NTIA identified a total of 255 MHz of Federal spectrum for reallocation to the private sector to provide additional spectrum for emerging telecommunications technologies and to help balance the Federal budget through subsequent auction of the identified bands.[9] Because of the large spectrum requirements of the Federal Government and the mandate to avoid excessive costs or serious degradation to Federal operations, most of these bands were identified with some degree of encumbrance. These encumbrances include continued Federal operations within certain bands at specific sites and continued Federal operations in adjacent bands. Introduction of new services and systems in the 17 bands identified for reallocation will open up a significant number of potential adjacent band interference problems. In the *Spectrum Reallocation Final Report*, NTIA recognized the potential problems and recommended that effective receiver standards, either regulatory or established by industry, be developed for new technologies operating in the reallocated bands adjacent to high-power Federal systems.[10]

Domestically, there has been no clear consensus regarding the best means to assure development and use of suitably designed receivers. Previously, the FCC declined to mandate standards for commercial receivers, stating that the pressures of the marketplace provide the best means to accomplish this goal. In some commercial areas, such as Personal Communications Service (PCS), system designers have successfully applied receiver standards. In other areas, especially where the consumers have access to products that achieve significantly different levels of performance, the lack of known standards and compliance may make it difficult for them to make an informed choice

1.2 Objectives

The objective of Phase 1 of this task was to undertake a broad review of receiver spectrum standards to characterize their status, both domestically and internationally. This Report presents the results of this phase.

Phase 2 will explore various alternatives and options to promote the use of receivers that are compatible with their operating environment, especially in commercial bands adjacent to Federal bands in which Federal high power equipment is operated. That phase will examine effectiveness trade-offs of various regulatory and voluntary approaches and develop appropriate recommendations.

1.3 Approach

Existing standards were compiled and reviewed in order to categorize the various types of standards and associated regulatory frameworks. In the sections that follow, particularly the tables, concise examples of different types of receiver standards are provided. For application of a standard, the complete referenced document should be consulted.[1]

Section 2
TECHNICAL BACKGROUND

This report focuses on potential non-cochannel interference of an unwanted transmitter on a victim receiver, and the standards that recommend receiver design parameters to prevent that interference

There are two modes whereby an undesired transmitter can interfere with a non-cochannel receiver. The first mode, usually regulated via limits on emissions outside the transmitter's authorized bandwidth, involves unwanted emissions from the transmitter falling in the receiver's tuned channel. The second mode involves several possible undesired responses of the receiver to the fundamental emissions in the transmitter's tuned channel. These modes are generally independent, the former being dependent on the transmitter's modulation and output filtering, and the latter on the receiver's selectivity, dynamic range, and intermodulation rejection capability. It is this second mode that is the subject of this report.

These non-cochannel interference mechanisms include:

- feed through of non-cochannel signals to the demodulator due to inadequate selectivity (filtering) at RF and IF stages;
- blocking due to an undesired very strong signal saturating the first amplifier stages and causing severe distortion
- receiver desensitization resulting from erroneous automatic gain control responses to non-cochannel signals;
- gain compression due to inadequate RF selectivity and dynamic range;
- spurious responses (to non-cochannel signals that mix with locally generated signals and fall within the receiver passband); and
- intermodulation of the desired and non-cochannel signals or two or more non-cochannel signals in non-linear stages of a receiver (e.g., in connection with gain compression).

The definitions of terms used to specify receiver standards vary among standardization bodies, especially for technical definitions that describe the means for measuring compliance. Thus, the source documents and associated publications, as well as the *IEEE Standard Dictionary of Electrical and Electronics Terms*, ITU Recommendation SM.332-4, *Selectivity of Receivers*, and Federal Standard 1037C, *Telecommunications: Glossary of Telecommunications Terms*, should be consulted for proper interpretation and application of the standards. Following are generalized definitions for receiver parameters and other technical terms used in this report:

- Adjacent Channel – A channel with bandwidth equal to, and abutting the desired signal channel

- Adjacent Channel Rejection (attenuation) – The ability of a receiver to reject signals in the adjacent channel.

- Adjacent Channel Selectivity – The ability of a receiver to discriminate between a desired signal and an undesired signal in an adjacent channel.

- Blocking – Saturation of the front end amplifier stage of a receiver by an undesired signal on a frequency different from that of the desired signal, thereby causing severe distortion and other non-linear effects that prevent proper operation of the receiver. This is also called the receiver saturation or blanking.

- Cross Modulation – The appearance of modulation from an unwanted signal on the desired signal.

- Image Frequency (of a heterodyne receiver) – The frequency removed from the local oscillator frequency, in the direction opposite to the direction of the desired signal frequency, by an amount equal to the intermediate frequency (i.e., difference between the desired channel frequency and the local oscillator frequency).

- Image Frequency Rejection – The ability of a receiver to reject signals at the image frequency.

- Intermodulation Rejection – The ability of a receiver to reject intermodulation products produced by the mixing of two or more signals at the input to the receiver.

- Necessary Bandwidth – For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

- Non-Cochannel Signal – Any signal or portion of a signal falling outside the authorized bandwidth of the desired signal.

- Occupied Bandwidth – The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage $\beta/2$ of the total mean power of a given emission. Unless otherwise specified, the value of $\beta/2$ should be taken as 0.5%. β equals the percentage of power outside the occupied bandwidth frequency limits.

- Out-of-Band Emission – Emission on a frequency or frequencies immediately outside the necessary bandwidth that result from the modulation process, but excluding spurious emissions.

- Selectivity – Rejection (attenuation) of an undesired signal at frequencies close to the desired signal frequency. It is often specified as the amount of frequency difference between desired and undesired signals needed to produce a specified attenuation of the undesired signal

- Sensitivity Depression or Desensitization – The level of a non-cochannel signal that increases a receiver signal power threshold or decreases receiver gain by a defined amount.

- Spurious Emission – Emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

- Spurious Response – Undesired receiver response resulting from mixing of the local oscillator and undesired signals. This includes the response to undesired signals at the image frequency.

- Unwanted Emissions – Both spurious emissions and out-of-band emissions.

Section 3
FEDERAL AGENCY STANDARDS

3.1 National Telecommunications And Information Administration (NTIA)

NTIA is responsible for managing Federal Government use of the radio spectrum. Its regulations, pertaining to Federal Government use of the frequency spectrum, are contained in the *Manual of Regulations and Procedures for Federal Radio Frequency Management.*[12]

The NTIA Manual provides receiver standards for most fixed systems below 15 GHz, most mobile systems below 420 MHz, and most radar systems as shown in Table 1. Generally, these standards include requirements for selectivity, spurious response rejection, and intermodulation rejection. These standards cover a large percentage of the authorized assignments in the Government Master Frequency File,[13] including the most congested Very High Frequency (VHF) and Ultra High Frequency (UHF) bands.

Table 1. Summary of NTIA Receiver Standards

NTIA Manual Section	Frequency Band	Service	Parameter	Requirement
3.9.7	162-174 MHz	VHF Inter-national Boundary and Water Commission	Selectivity	90 dB
			Intermodulation Rejection	80 dB
			Spurious & Image Rejection	100 dB
5.3.1	HF 3 – 30 MHz	Fixed & Mobile	Selectivity	The pass band shall be no greater than the authorized bandwidth of emission and the slope of the selectivity outside the pass band shall be 100 dB/kHz
5.3.3	406.1 - 420 MHz, 932-935/941-944 MHz, 1 71 - 15.35 GHz	Fixed	Spurious Rejection	The receiver unwanted signals shall be attenuated at least 60 dB relative to the receiver sensitivity at the center of the pass band
			Selectivity	The 3 dB receiver bandwidth should be commensurate with the authorized emission bandwidth plus twice the frequency tolerance of the transmitter. The 60 dB receiver bandwidth shall not exceed five times the 3 dB receiver bandwidth

Table 1. Summary of NTIA Receiver Standards (continued)					
NTIA Manual Section	Frequency Band	Service	Parameter	Requirement	
5 3 5.1	29.7-50 MHz, 162-174 MHz, 406 1-420 MHz	Fixed & Mobile (Wide Band)	Spurious Rejection	All exc. portable: Portable: (depending on band)	85 dB 50-60 dB
			Adjacent Channel Rejection (Analog)	All exc. portable: Portable:	80 dB 50-70 dB
			Adjacent Channel rejection (Digital)	All exc. portable: Portable:	50-55 dB 50 dB
			Intermodulation Rejection	All exc. portable: Portable:	60-70 dB 50 dB
5.3.5 2	138-150.8 MHz, 162-174 MHz, 406.1-420 MHz	Fixed & Mobile (Narrow Band)	Spurious Rejection	All exc. portable: Portable:	70 dB 60 dB
			Adjacent Channel Rejection	All exc. portable: Portable:	60-70 dB 50-60 dB
			Intermodulation Rejection	All exc. portable: Portable:	70 dB 50 dB
5.5 2	2.9-40 GHz	Radars (Criteria B)	Selectivity	The overall receiver selectivity characteristics shall be commensurate with or narrower than the transmitter bandwidth	
			Spurious Rejection, excluding image	50 dB, except where broadband front ends are required	
			Stability	Frequency stability of receivers shall be commensurate with, or better than that of the associated transmitter	

Table 1. Summary of NTIA Receiver Standards (continued)				
NTIA Manual Section	Frequency Band	Service	Parameter	Requirement
5 5 3	All Radar Bands	Radars (Criteria C)	Selectivity	The overall receiver selectivity characteristics shall be commensurate with or narrower than the transmitter bandwidth. Receivers shall be capable of switching bandwidth limits to appropriate values whenever the transmitter bandwidth is switched
			Spurious Rejection, excluding image	60 dB
			Image rejection	50 dB
			Stability	Frequency stability of receivers shall be commensurate with, or better than that of the associated transmitter
5.5 4	2.7-2 9 GHz	Radars (Criteria D)	Selectivity	The overall receiver selectivity characteristics shall be commensurate with or narrower than the transmitter bandwidth. Receivers shall be capable of switching bandwidth limits to appropriate values whenever the transmitter bandwidth is switched
			Spurious Rejection, excluding image	60 dB
			Image Rejection	50 dB
			Stability	Frequency stability of receivers shall be commensurate with, or better than that of the associated transmitter

Table 1. Summary of NTIA Receiver Standards (continued)				
NTIA Manual Section	Frequency Band	Service	Parameter	Requirement
			Receiver Interference Suppression Circuitry	Radar systems should have provisions incorporated into the system to suppress pulsed interference. The following information is intended for use as an aid in the design and development of receiver signal processing circuitry or software to suppress asynchronous pulsed interference. A description of the parametric range of the expected environmental signal characteristics at the receiver IF output is: Peak I/N ratio:<50 dB Pulse width: 0.5 to 4.0 μs PRF: 100 to 2000 pps
5.5.5	449 MHz	Radar (Criteria E, Wind Profiler Radars)	Selectivity	The 3 dB receiver bandwidth should be commensurate with the authorized emission bandwidth plus twice the transmitter frequency tolerance of 10 parts per million (ppm). The 60 dB receiver bandwidth shall be commensurate with the 60 dB emission bandwidth. Receivers shall be capable of switching bandwidth limits to appropriate values whenever the transmitter bandwidth is switched
			Spurious rejection, excluding image	60 dB
			Image Rejection	50 dB
			EMC Provision	Radars shall have the capability to tolerate incoherent pulsed interference of duty cycles less than 1.5 percent such that peak interfering signal levels 30 dB greater than the receiver noise level at the IF output will not degrade performance